

# Model of Container Transport System in Long Distance Freightage – Analysis and Optimalization of Supply Chain

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This article is about the integration idea of rail and road long-distance transport to increase the efficiency of the transport chain. The article compared two transport models - conventional (using road transport) and intermodal transport (using road and rail transport). The proposed intermodal model uses the Container Transport System for freight transport in relation: consolidation point (company) – container terminal – rail transport – container terminal – deconsolidation point and radial transport system of road transport to ensure door-to-door delivery. The model was examined to optimize cost, time, capacity and environmental factors. Moreover, in the article the main features of both models were identified and compared. Freight rates and the prices given in the article are consistent with the actual rates charged by carriers, but they are not an offer.

**Keywords:** Container transport system, supply chain, international transport, transport model, optimization of freight transport, UTI.

## 1. INTRODUCTION

Increase in fuel prices results in an increase of freight rates particularly noticeable in road transport. The cost of the transport process is therefore an increasing proportion of the total cost of the product which reaches the market. This is even more accentuated regarding the goods of small value and in the case when a product must be reloaded several times before it reaches its destination. Additionally, each reloading in the transport process exposes an additional loss of time and may be the cause of delays resulting from the needs which include: checking documents, goods, weather conditions hindrance or even prevent reloading and damage to cargo in one of the earlier stages of the transport chain. In order to minimize the cost of transport it is necessary to improve supply chain management and often use several modes of transport, such as intermodal road and rail transport.

Taking into account the statistics of the European Commission, Eurostat, the volume of freight road transport and rail transport in Poland is classified as one of the leading European

countries<sup>1</sup>. Data illustrating the changes in the amount of cargo transported in Poland compared to the most active countries in the European Union in the years 2004-2010 are presented in Figure 1 and Figure 2.

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<sup>1</sup> Webpage: <http://epp.eurostat.ec.europa.eu> state as on 21.05.2012

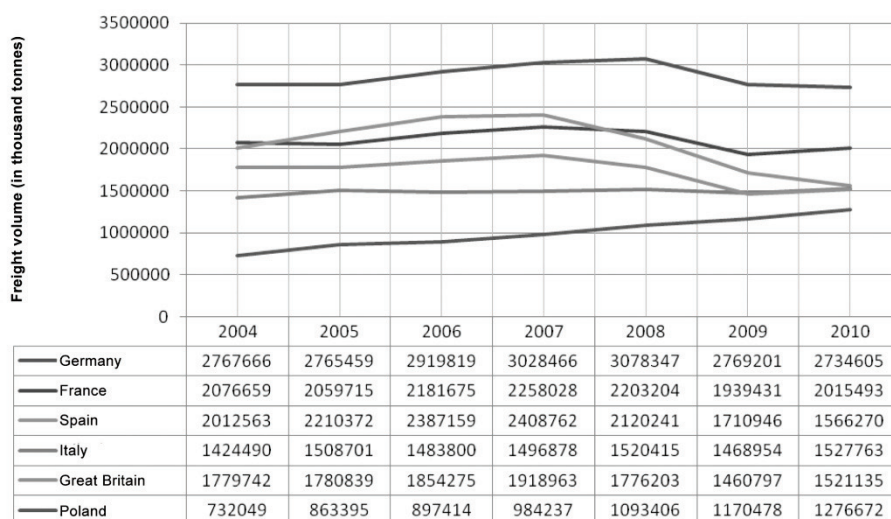


Fig. 1. The volume of freight road transport, 2004-2010

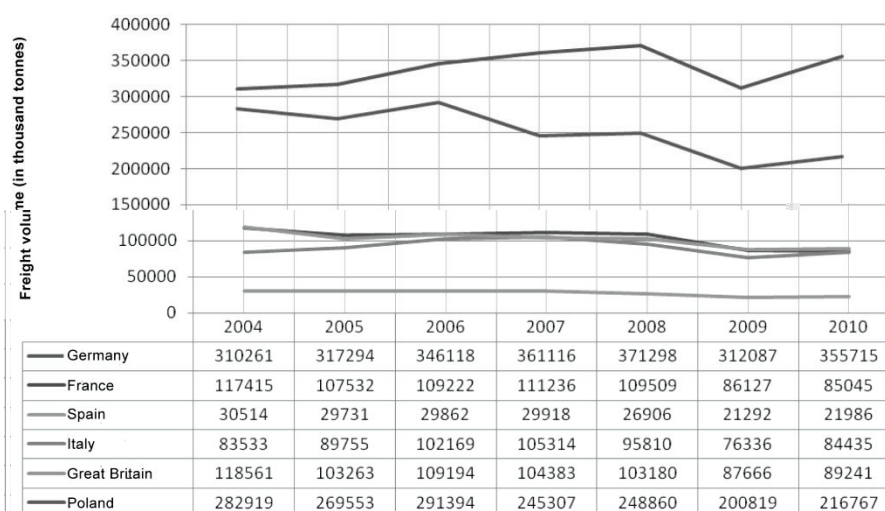


Fig. 2. The volume of rail freight in 2004-2010

Basing on the presented data it can be concluded that Poland has a great potential for using road transport. Therefore, the aim of this paper is to analyze the carriage of goods by rail and road in terms of cost, time, transport, taking into account capacity and ecological factors. The paper has also taken into consideration the issue of integration of the two modes of transport in order to optimize the whole transport chain.

## 2. THE DOMESTIC ROAD AND RAIL TRANSPORT

In order to analyze road and rail transport a similar route was established between two locations - the same in both cases. These are: Małaszewicze (station code 040600, Post Code 21-540) and Kobylnica (station code 031021, Post Code 61-302). The connections between these locations are presented in Table 1. As a kind of

cargo selected neutral goods, class NHM 851430 - other stoves, electric.

Table 1. Transportation of cargo (NHM 851,430) between the locations Kobylnica and Małaszewicze

	Conventional rail transport <sup>2</sup>	Intermodal rail transport <sup>3</sup>	Conventional road transport
Real distance [km]	491	491	482.8 <sup>4</sup>
Cargo weight [t]	22	22	22
Method of transportation / load units	A two-axle wagon Kgns, body length 12.5m	A two-axle wagon Kgns, container 40'	Semitrailer (tilt) 13.6x2.45x2.60 m
Rate of freightage [PLN]	4548.42 / 206.75 per ton	3487.00	1156.00
Driving time	8 h	8 h	7 h

<sup>2</sup> Webpage: [www.koleja.pl](http://www.koleja.pl) state of 22.05.2012

<sup>3</sup> Webpage: [www.koleja.pl](http://www.koleja.pl) state of 22.05.2012

<sup>4</sup> Webpage: [www.emapi.pl](http://www.emapi.pl) state of 22.05.2012

Comparing all the cases shown in Table 1, a significant difference in freight cost can be noted. The weight of the load and its dimensions are comparable - 212Z Kgn wagon load length of 2.74m width 12.5m, container 40 '1A dimensions: 2.438m x 12.192m and semi-trailer with dimensions 13.6m x 2.45m. It was assumed that there is no possibility to benefit from discounts for any mode of transport. Discounts are accrued on the contract and orders are mainly dependent on the volume of transport, distance and type of cargo. For road transport assumed rate PLN 2.50/km - which corresponds to the current average rates of transport.

In conclusion, if we deal with a cargo carriage of a small volume within the country and there is no need for multiple handling, this is the cheapest way – road transport. Therefore the use of intermodal transport is not viable in this case.

### 3. INTERNATIONAL ROAD AND RAIL TRANSPORT

As previously stated, national intermodal transport is not economically feasible because of the small volume of transport and the relatively short distance. The situation is different in the case of intermodal transport for the transport of large amounts of cargo over a long distance. It will be possible in this case to sign a contract with the carrier taking advantage of discounts granted by him.

A good example of this type of process is transporting cargo from Asia to Europe, where the prices of manufactured goods are much lower than in Europe. For this reason, many products are imported, in spite of a large distance to be covered, and therefore, high cost of carriage. In order to reduce the costs different types of transport combinations are sought for<sup>5</sup>.

For goods imported from eastern Asia using the most inexpensive but slow connection - sea container and air transport is expensive but fast. The aim is to obtain the intermediate value between the cost and time for both modes of transport. The role of road transport in this case is limited in practice to connecting the individual links for transportation and delivery of the first and last stage of the process. The situation is different for transporting goods from Russia to Europe

because of the limitation on carriage of goods by sea, road and rail transport is used. Due to the increasing cost of road transport and a high risk of damage or theft of cargo, conventional transport is often replaced by rail transport.

There is also used a combination of both types of transport, a good example of which is container transport<sup>6</sup>.

The combination cost of Moscow - Warsaw freight is highly dependent on whether it is possible to find loads in Russia or whether a vehicle is forced to return with an empty trailer. In practice it is not easy to find a returning cargo in a convenient time, and the waiting time between unloading and the next loading may be too long and too costly. It is a tough market because Russian carriers reduce freight rates due to low fuel prices ranging PLN 3.18/liter<sup>7</sup> - the price was valid on 25.05.2012. For the carriage of cargo along the planned route using tractor and semi-tilt transport costs are in the range from EUR 2,100 to 2,400 - if the carriage returns with no loads. However, having ensured a return cargo from Russia to Poland, the cost of transportation may be reduced up to EUR 800-900. While the cost of transporting a container 40' by road will almost always be the maximum rate. This is due to the fact that there is no physical possibility of carrying goods using other units than the container, and container cargos are still not popular enough. Therefore in this case, taking into account the expected cost of conventional transport in both directions, the cost will be around EUR 2,400. Using container as a cargo unit for the transportation of loads by rail, one can get a much better rate. The distance from Moscow - Terespol - Warsaw is 1179 km, and therefore according to the Cargo Sped S.A. rates the basic fee for carriage is 1,894.13<sup>8</sup>. The final fees vary depending on the size and weight of the units. The correction coefficients are presented in Table 2.

<sup>5</sup> J. Witkowski, Zarządzanie łańcuchem dostaw, koncepcje > procedury > doświadczenia, wyd. PWE, Warszawa 2010.

<sup>6</sup> A. Harrison, R. van Hoek, Logistics Management and Strategy Competing through the supply chain, 3rd edition, Pearson Education Limited, England 2008.

<sup>7</sup> Webpage: <http://gasoline-germany.com> state of: 28.05.2012

<sup>8</sup> Commodity Rate of PKP Cargo S.A.: <http://www.cargosped.pl> state of: 28.05.2012

Table 2. Correction factors for UTI packages<sup>9</sup>

Code of length	Container length in British feet	Length of the container and the vehicle swap body	Correction factors for UTI packages		
			UTI cargo up to 22 tons gross	UTI cargo of more than 22 gross tons	Empty UTI
10	20	≤6,15	0,55	0,75	0,37
20	25	6,16-7,82	0,55	0,75	0,37
30	30	7,83-9,15	0,75	0,75	0,50
40	35	9,16-10,90	0,85	1,00	0,65
50	40	10,91-13,75	1,00	1,10	0,70
60	45 and more	≥13,76	1,00	1,10	0,70

Taking into account transport of container 40' comparable to the standard trailer (tilt) and its maximum weight of 24 tons, the basic rate remains unchanged and amounts to EUR 1,894.13. However, for the weight less than 22 tonnes, the

The rail freight fee depends on the volume of transport. For contracts it is possible to obtain discount from the carrier, sometimes amounting to 40% for the large quantities of transported cargo.

#### 4. CONVENTIONAL AND INTERMODAL TRANSPORT MODEL

In conventional freight carried by road vehicles, the cargo is delivered directly from the manufacturer to the final destination point – *door-to-door*. However, in the intermodal transport chain what must also be taken into consideration are the links between the manufacturer of the goods and railway container terminal and the container terminal with the destination points. Model of conventional and intermodal transport is shown in Figure 3.

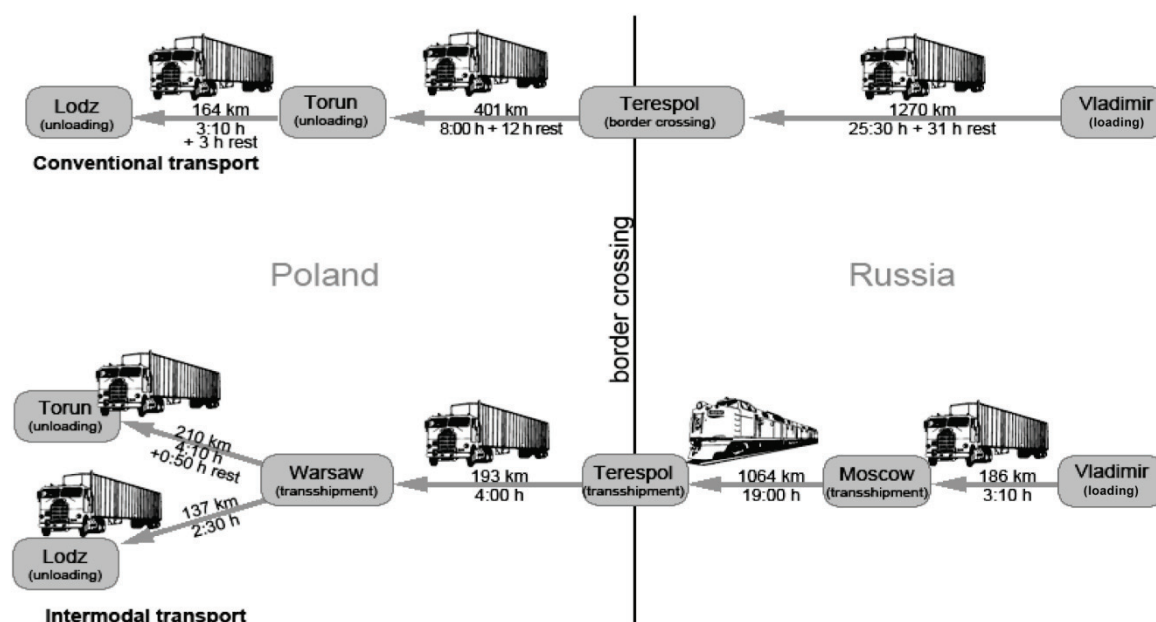


Fig. 3. Model of conventional and intermodal transport (own study)

rate should be adjusted to EUR 1,610.01. On the other hand when using two containers of 20' the cost of transportation is:  $2 \cdot \text{EUR } 1,894.13 \cdot 0.55 = \text{EUR } 2,083.54$ .

Extra fee for loading and unloading of UTI must be added to the freight rates, and if it is required, also for the unloading container in the storage place. This fee is EUR 39.20 per load / unloading / reloading. In the case of storage place no additional costs are incurred for the first 14 days. After this period one will be charged € 4 per storage day of one 40' UTI.

Models shown in Figure 3 can be compared in terms of transport costs and travel time. Arrows show various connecting points in the transporting chain. Distance and travel time between them is also given. Conventional transport model takes into account transport realized only by one tractor unit from city Vladimir without handling the goods. Lodz and Torun are cargo destination points towns, so the vehicles in this case must first unload goods in Torun, and then the next part of cargo in Lodz. The intermodal transport model was planned to load goods into two containers of 20' in Vladimir. The cargo will be transported on one trailer to the container terminal in Moscow, where it will be handled into one two-axle wagon. Then it

<sup>9</sup> Commodity Rate of PKP Cargo S.A.: <http://www.cargosped.pl> state of: 28.05.2012

will be transported to the transshipment terminal in Terespol, where it will once again be handled onto a common semi-trailer and will be transported to Warsaw. In Warsaw, deconsolidation of the containers takes place and they are transported by two different vehicles to two different target points - Torun and Lodz. Summary of transport costs and time for both models is presented in Table 3.

When analyzing Table 3, it can be seen that the cost of intermodal transport is lower than the transport of two 20 feet containers and there is no discount. In addition, delivery times are shorter, which is mainly caused by the fact that most of the roads containers are transported by rail, so there is no need to make additional standstills for the driver to rest. In both models driver's working time was included in accordance with the Polish Act on the working time of drivers<sup>10</sup>. In the case of a single driver transporting the cargo the time for the analyzed model is more than twice the size of intermodal transport (85:40 hours). Intermodal transport model presented in the last stage of the process is carried out using the radial transport method. It consists of deconsolidation of cargo and transporting it separately by two vehicles to the destination places<sup>11</sup>.

Table 3. Summary of the cost and time for the conventional and intermodal transport model

Conventional transport model			Intermodal transport model		
Part of the route	Cost EUR <sup>12</sup>	Time [h]	Part of the route	Cost EUR <sup>13</sup>	Time [h]
Vladimir – loading	-	1:00	Vladimir - loading	-	1:00
Vladimir – Terespol	2,540.00	25:30 + 31:00 rest	Vladimir - Moskwa	204.00 <sup>14</sup>	3:10
Terespol – Toruń	800.00	8:00 + 12:00 rest	Moscow - transshipment <sup>15</sup>	78.40	0:20
Toruń – unloading	-	1:00 + 3:00 rest	Moscow – Terespol	1,841.54	19:00
Toruń – Łódź	328.00	3:10	Terespol - transshipment	78.40	0:20

<sup>10</sup> Act on working time of drivers of 16 April 2004 (Journal of Laws of 2004 No. 92, item. 879) - Text in force since January 1, 2012

<sup>11</sup> C. Bozarth, R. B. Handfield, Wprowadzenie do zarządzania operacjami i łańcuchem dostaw, wyd. Helion, Gliwice 2007.

<sup>12</sup> Assuming the rate of 2€/km

<sup>13</sup> Assuming the rate of 2€/km

<sup>14</sup> Assuming the rate of 1.1€/km

<sup>15</sup> Handling two containers 20' – 39,20€/unit, 0:10 h/unit.

Łódź – unloading	-	1:00	Terespol - Warszawa	386.00	4:00
			Warszawa - deconsolidation	39.20	0:10
			Warszawa - Toruń	420.00	4:10 + 0:50 rest
			Toruń – unloading	39.20	0:10
			Warszawa - Łódź	274.00	2:30
			Łódź - unloading	39.20	0:10
<b>Sum:</b>	<b>3,668.00</b>	<b>85:40</b>		<b>3,399.94</b>	<b>33:10</b>

Another advantage is the high container traffic load safety factor. The container starts its route from the production company and until the destination point it is not opened but secured by plug. Using two containers of 20' is more efficient because when transporting the cargo to two recipients repackaging of it is not necessary. It is only reloaded into a single container from one trailer to another.

There are more loading operations in intermodal cargo transport, but the risk of damaging the cargo is very low because the container is transshipped between different modes of transport, not its contents<sup>16</sup>. Minimizing the risk of damage to the cargo is particularly important for high value goods. In the presented model for the container transport, there were six loading processes. This is more than a conventional transport model, where there were only three similar processes. Summary of the advantages and disadvantages of both transport models is presented in Table 4

Table 4. Summary of the main features of conventional and intermodal transport models

	Conventional transport model	Intermodal transport model
<b>Driving time</b>	Long	Short
<b>Costs, without discounts</b>	Slightly higher	Slightly lower
<b>Possibility of obtaining discounts</b>	Slightly to 10%	Up to 40% for large volume
<b>Number of reloadings</b>	3	6
<b>Documents</b>	CMR, TIR Carnet	CMR, TIR Carnet, SMGS
<b>Risk of damage to cargo</b>	Medium	Low
<b>Emission standards</b>	EURO standard	Directive 97/68/EEC

<sup>16</sup> P. R. Murphy jr, D. F. Wood, Nowoczesna logistyka, Wydanie X, wyd. Helion, Gliwice 2011.

## 5. EMISSION STANDARDS

Due to the growing pollution of the environment it is important to reduce the emissions in the transport process. Therefore increasingly stringent regulations and standards were formed, harmonized in many countries. Current standards for road and rail transport are presented in Table 5

Table 5. Emission standards for diesel engines EURO standard and Directive 97/68/EC<sup>17,18</sup>

		CO (g/km)	HC (g/km)	Nox (g/km)	PM (g/km)	valid from
EURO	EURO 4	0,5	0,05	0,25	-	01-05-2005
	EURO 5	0,5	0,05	0,18	0,005	01-09-2009
	EURO 6	0,5	0,09	0,08	0,005	01-08-2014
		CO (g/kWh)	HC (g/kWh)	Nox (g/kWh)	PM (g/kWh)	valid from
III A	RC A, P > 130 kW	3,5	4		0,2	01-01-2006
	RL A, 130 kW < P < 560 kW	3,5	4		0,2	01-01-2007
	RH A, P > 560 kW	3,5	0,5	6	0,2	01-01-2009
	RH A, P > 2000 kW i SV > 5l/cyl	3,5	0,4	7,4	0,2	01-01-2009
II B	RC B, P > 130 kW	3,5	0,19	2	0,025	01-01-2012
	R B, P > 130 kW	3,5	4		0,025	01-01-2012

It should be noted that emission standards for road transport are expressed in g / km and for rail transport in g / kWh. In order to compare them we have to convert them to common units. In order to do this it is necessary to compare the specific engine, but it is also indicative comparison of the two standards. Assuming tractor engine power as a 440HP (330kW), and the average speed rate of 60km / h the emission standards in g / kWh may be calculated. However, to calculate the standards for locomotives value from norm must be multiplied by the power of the standard engine. For the adopted comparative purposes, the locomotive engine power is equal to 800kW. The converted data are presented in Figure 4.

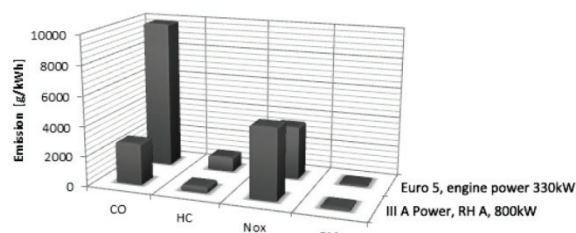


Fig. 4. Comparison of emission standards for road and rail transport (own study)

## 6. CONCLUSION

This article compares two models of long-distance transport. It is shown on the example of connection between Russia and Warsaw that in this type of transport it is cost-effective to use container transport while road transport integration with rail transport enables *door-to-door* delivery.

Even with standard carriage for two 20' containers without discounts offered by carriers for the largest volume of transport, transport cost is lower than that of conventional road transport. In addition, the transport time is almost twice as low, and the goods carried all the way in one transport unit are better protected against damage. From the initial analysis of emission standards it may be noted that intermodal transport is more environmentally friendly and less polluting than the conventional road transport.

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<sup>17</sup> Webpage: <http://europa.eu> state of: 28.05.2012

<sup>18</sup> Directive 97/68/EC of the European Parliament and of the Council of 16 December 1997

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